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Electro Scientific Industries

7524 S. W. MACADAM AVENUE • PORTLAND 19, OREGON

INSTRUCTION MANUAL

ESI Model 270

CAPACITANCE MEASURING SYSTEM

ELECTRO SCIENTIFIC INDUSTRIES
7524 S. W. Macadam Ave.
Portland 19, Oregon

November, 1962

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Electro Scientific Industries
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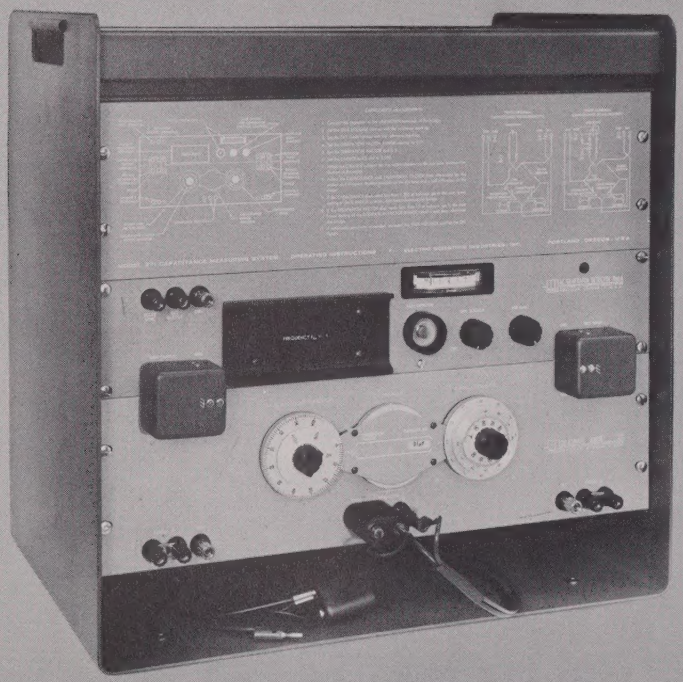
Catalog Sheet

BRIDGES AND ACCESSORIES

C-15

DECEMBER 1962
REPLACES MARCH 1962



CAPACITANCE MEASURING SYSTEM

MODEL 271

Wide Range Measurements with 0.1% Accuracy

The ESI Model 271 Capacitance Measuring System consists of the ESI Model 277 Capacitance Bridge and the ESI Model 860A AC Generator-Detector mounted in a custom metal cabinet. The system has a wide range measurement capability using the precision bridge, matched generator and sensitive detector. Shielded test leads and front panel operating instructions simplify accurate measurements. Extended capacitance and dissipation factor range is available in the ESI Model 271H Capacitance Measuring System which features the ESI Model 277H Capacitance Bridge.

The Model 277 Capacitance Bridge measures two and three-terminal capacitors to 120 μf with a resolution of 0.01 picofarads on the lowest range. The Model 277H will measure to 1200 microfarads with a resolution of 0.1 picofarads on the lowest range. The unknown capacitor is measured in terms of the capacitance and dissipation factor of its equivalent series circuit. Stray capacitance in parallel with the unknown is eliminated by internal bridge shielding and by the use of shielded leads. Capacitance value and dissipation factor are presented as coaxial dial in-line readouts for fast, error-free measurements.

The Model 860A AC Generator-Detector consists of a voltage source and sensitive tuned detector designed to optimize bridge performance. The generator provides up to 15 volts output and is power limited to 0.1 watt for circuit protection. The detector is tuned to the generator frequency to minimize harmonic response and hum pickup. The panel-mounted meter gives easily observed null variations and the electron ray null indicator give instantaneous response to signal changes for rapid, precision bridge balancing. Detector output and synchronization terminals are available for connecting an external null indicator.

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Specifications

MODEL 277

Capacitance Readings

Number of Ranges:	Seven.
Dial Resolution:	12,005 divisions full scale on any range.
Highest Range:	0 to 120 μf.
Lowest Range:	0 to 120 pf; 1 dial division represents 0.01 pf.
Accuracy*:	On the five intermediate ranges: ±(0.1% + 1 dial division). On highest range and lowest range: ±(0.2% + 1 dial division).

Dissipation Factor Readings

Number of Ranges:	Three.
Dial Resolution:	105 divisions full scale on any range.
Highest Range:	0 to 1.05 x frequency in kilocycles.
Lowest Range:	0 to 0.0105 x frequency in kilocycles; at 1 kc, 1 dial division represents a D of 0.0001.
Accuracy*:	±(2% + 0.0005).

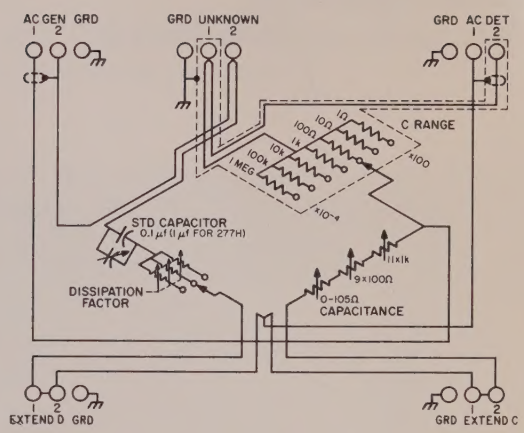
MODEL 277H

Capacitance Readings

Highest Range:	0 to 1200 μf.
Lowest Range:	0 to 1200 pf; 1 dial division represents 0.1 pf.
Accuracy*:	On the five intermediate ranges: ±(0.1% + 1 dial division). On highest range and lowest range: ±(0.2% + 1 dial division).

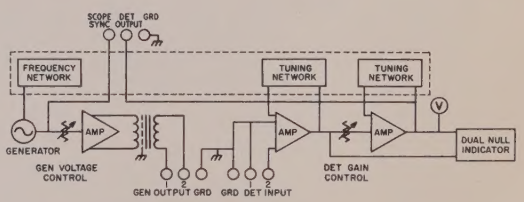
Dissipation Factor Readings

Highest Range:	0 to 10.5 x frequency in kilocycles.
Lowest Range:	0 to 0.105 x frequency in kilocycles; at 1 kc, 1 dial division represents a D of 0.001.
Accuracy*:	±(2% + 0.0005).



MODEL 860A

Generator Voltage:	0 to approximately 15 volts. Internal resistance is approximately 600 ohms. Generator output terminals are insulated from ground and have capacitance to ground of less than 30 pf.
Generator Frequency:	1 kilocycle network, accurate to ± 1% supplied. 0.1, 0.4 and 10 kilocycle units available. Units between 0.05 and 10 kilocycles made to order.
Detector Indicator:	Meter plus electron ray null indicator with instantaneous response to signal changes. Dual display for strong and weak signal changes.
Detector Sensitivity:	At maximum gain, meter and lower half of eye respond to signals, approximately 20 microvolts to 0.01 volts. Upper eye between 0.01 volts and 5 volts.
Detector Selectivity:	Network tuned to generator frequency. Second harmonic response down at least 30 db.
Power Supply:	115 volts, 50/400 cycles. 230 volt transformer available.

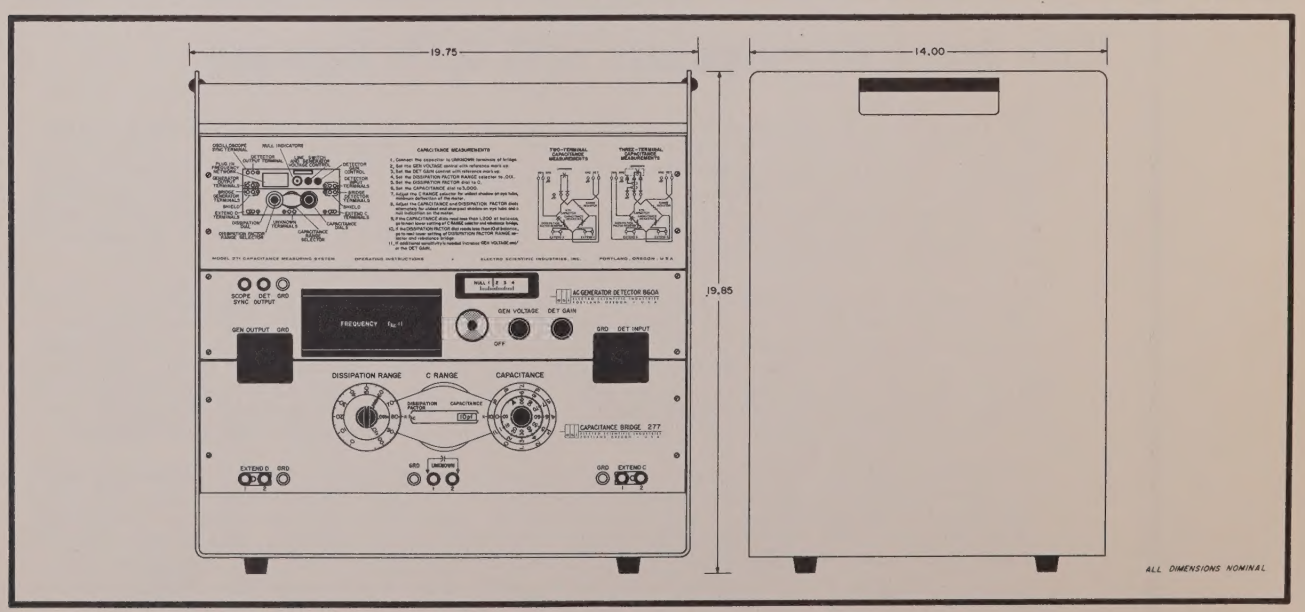


PHYSICAL SPECIFICATIONS

MODEL 271 and 271H	DIMENSION	19.75 W x 19.85 H x 14 D	NET WEIGHT 50 lbs	PRICE $ 650.00
277 and 277H		19 W x 7 H x 7 D	18 lbs	310.00
860A		19 W x 3 1/2 H x 8 D	10 lbs	280.00

PART NO. 1560 Shielded lead set (included with Model 271 and Model 271H) 12.00

*NOTE: Accuracy ratings apply at a frequency of 1 kc and at a temperature of 25°C. Slightly larger errors may be encountered at frequency or temperature extremes. Capacitance accuracy specifications apply when the bridge has been recently standardized against a reference standard capacitor. The long-term drift in calibration will not exceed 0.1% per year (Model 277), 0.2% (Model 277H) and any such drift can be corrected by a single adjustment to restandardize the bridge against any certified reference standard capacitor.



Electro Scientific Industries

7524 S. W. Macadam Avenue, Portland 19, Oregon

(formerly Electro-Measurements)

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1. INTRODUCTION

The ESI type 270 CAPACITANCE BRIDGE is a portable, self-contained instrument for the rapid and accurate measurement of capacitance. Values of equivalent series capacitance and dissipation factor can be read directly from the dial settings.

The unit consists of an accurate, well-shielded capacitance bridge, including associated generator, detector, and indicator. The case and controls have been human-engineered for maximum accuracy and operator convenience. All the necessary controls are located and clearly identified on the front panel. The adjustable legs permit tilting the instrument to any convenient angle, and can also be positioned to provide a carrying handle.

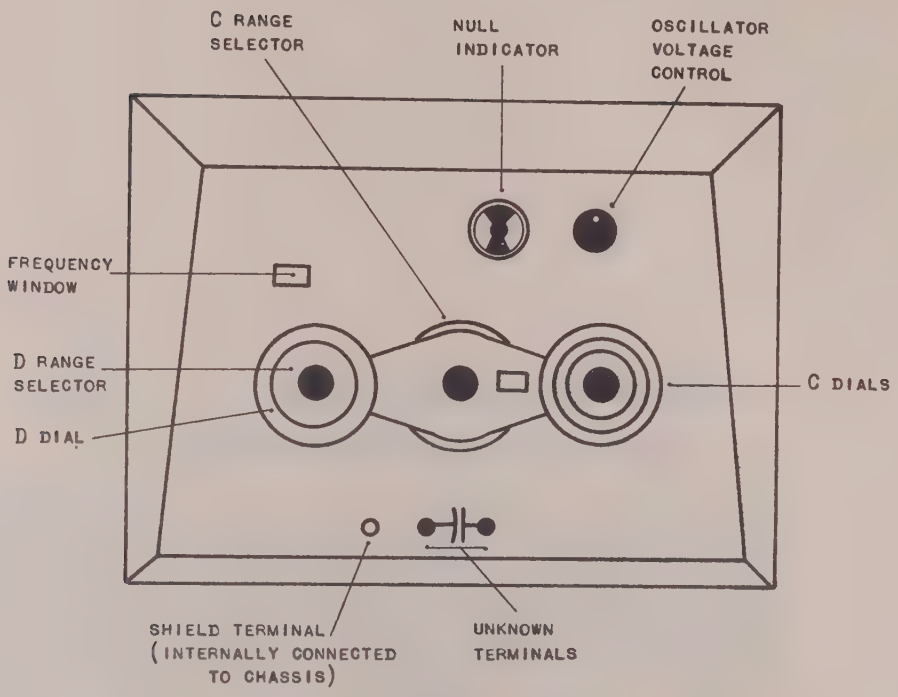
2. OPERATING INSTRUCTIONS

2.1. WHAT THE BRIDGE MEASURES

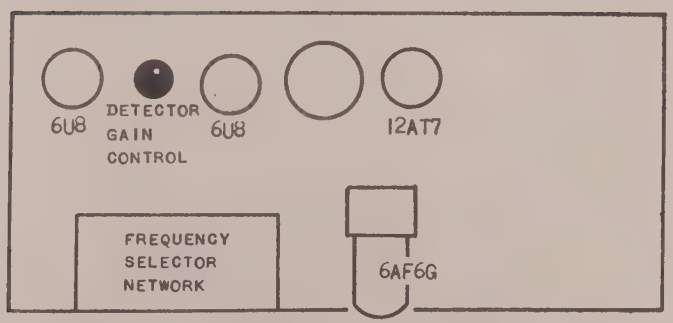
The Model 270 bridge measures "direct" capacitance, with the unknown capacitor connected in an ungrounded arm of the bridge. Stray capacitance and leakage in parallel with the unknown capacitor are eliminated by grounded shielding. This permits the measurement of small three-terminal capacitors to better than 0.01 uuf. without the use of a guard circuit or Wagner ground.

If it is necessary to measure grounded capacitance, the internal connections of the bridge may be changed by means of a special cable assembly.

MODEL 270 PANEL ARRANGEMENT



TOP VIEW OF 270 CHASSIS (COVER RAISED)



2.2. CONTROLS

2.2.1. Frequency Selecting Network

The plug-in unit determines the operating frequency of both the generator and detector.

2.2.2. Dissipation Factor Range Selector

The inner left-hand dial selects from three dissipation factor ranges.

2.2.3. Dissipation Factor (D dial)

The outer left-hand dial indicates the magnitude of the dissipation factor when its indicated value is multiplied by the dissipation factor range selector setting and the frequency in kilocycles.

2.2.4. Capacitance Range Selector.

The center dial selects from seven available capacitance ranges.

2.2.5. Capacitance Value Dials (C dials)

The reading of the three dials on the right, multiplied by the capacitance range setting, is the value of the capacitance of the unit connected to the unknown terminals.

2.2.6. Null Indicator

The dual electron ray null indicator provides an extremely broad range of sensitivity. The upper eye responds to large signals and the lower eye responds to very weak signals. A null is indicated by the maximum opening of both eyes.

2.2.7. Unknown Terminals

The unknown terminals have been located below the dials to provide maximum lead accessibility and easy use of the dials without excessive hand capacitance.

2.2.8. Oscillator Voltage Control

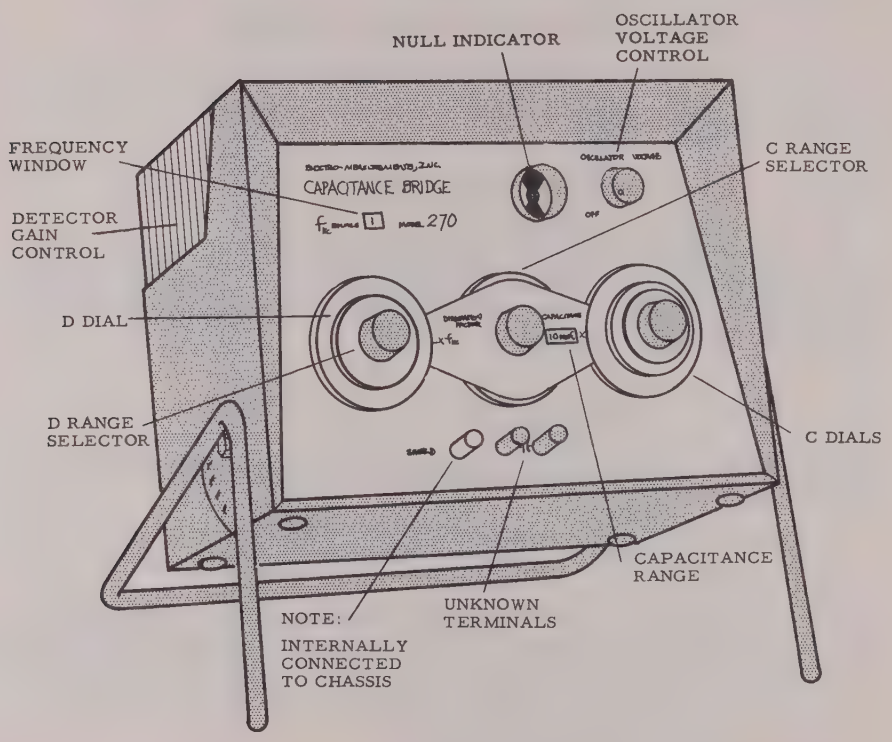
This knob controls the output voltage of the oscillator and operates the external power switch

2.2.9. Detector Gain Control

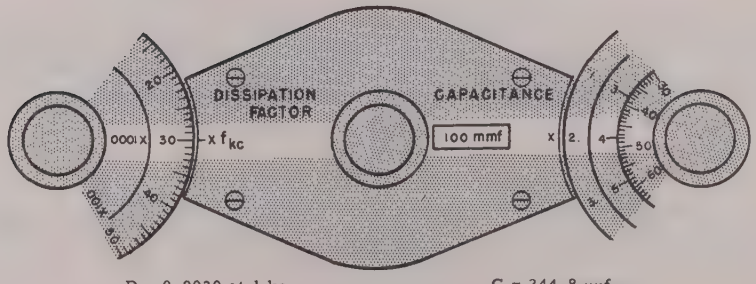
For added flexibility, there is a knob inside the case to adjust the detector gain. Clockwise rotation increases the gain. Where hum pickup is unavoidable, often measurements can be made more easily by reducing the detector gain and increasing the oscillator voltage.

The detector gain control affects only the more sensitive lower half of the eye.

MODEL 270 CAPACITANCE BRIDGE



"IN LINE" READ-OUT



D = 0.0030 at 1 kc

C = 244.8 μμf.

2.3

MEASURING CAPACITANCE

the esi way

2.3.1. Basic Instructions

Connect the capacitor to the UNKNOWN TERMINALS (marked).

Set the OSCILLATOR VOLTAGE control with the dot up.

Set the DETECTOR GAIN CONTROL to maximum. (This control is inside the case and is ordinarily left at maximum.)

Set the D RANGE SELECTOR at .01X.

Set the D DIAL at 0.

Set the C DIALS to read 3.000.

Adjust the C RANGE SELECTOR for maximum opening of the null indicator.

Adjust the C DIALS and the D DIAL alternately for maximum opening of the null indicator.

If additional sensitivity is needed, turn the OSCILLATOR VOLTAGE CONTROL clockwise.

If the C dial reading is less than 1.200, go to the next lower setting of the C range selector.

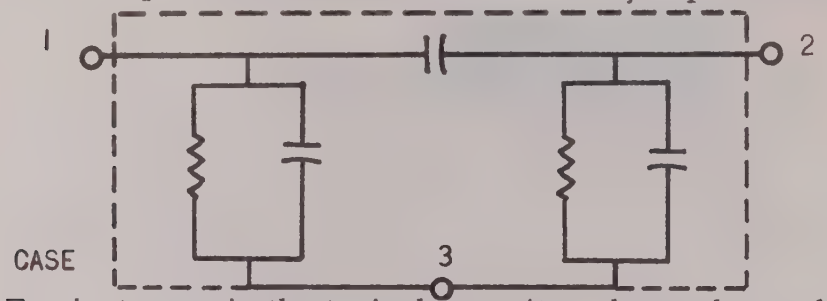
If the D dial reading is less than 10, go to the next lower setting of the D range selector.

The values of series capacitance C and dissipation factor D are as follows:

C = (C range selector setting) x (C dial reading)
D = (D range selector setting) x (D dial reading) x (f_{kc})

2.3.2. Three-Terminal Capacitors

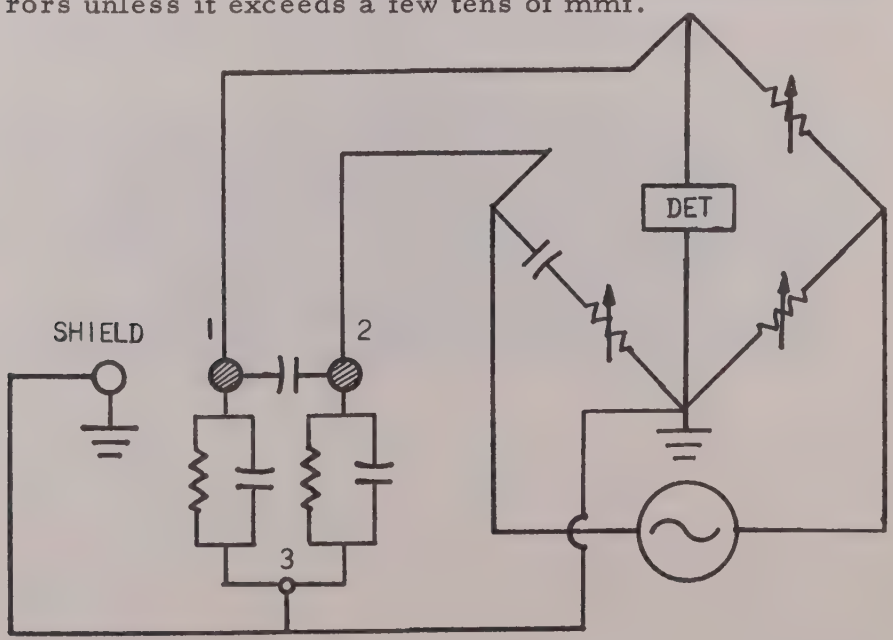
Three-terminal measurements make it possible to measure direct capacitance accurately by isolating the unknown capacitor from the effects of stray capacitances.



For instance, in the typical capacitor shown above, there is stray capacitance from each plate to the case and leakage resistance. With two-terminal techniques, this causes an error in measurement. The bridge reading does not give the capacitance between the plates, but the total impedance of the entire network as seen from terminals 1 and 2

To isolate the direct capacitance, the capacitor case is used as a third terminal and is connected to the shield terminal of the bridge. If one of the stray capacitances is known to be greater, it should be connected from the center terminal to the shield terminal of the bridge. Thus this stray capacitance appears across the detector where it will cause no error. However, large values may reduce the detector sensitivity.

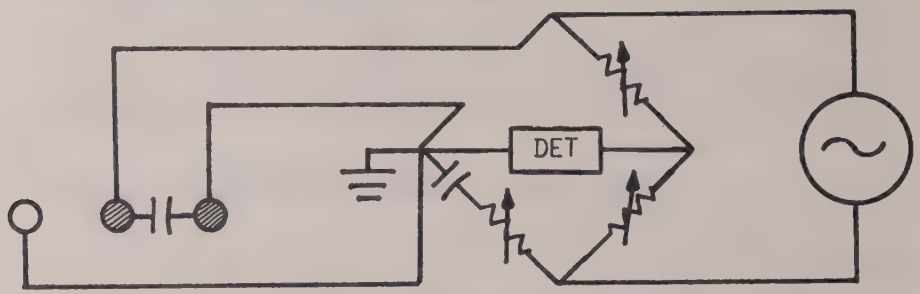
The other stray capacitance is then across the standard capacitor arm of the bridge, in parallel with the standard capacitor. As the standard capacitor is 100,000 mmf, the stray capacitance will not cause significant errors unless it exceeds a few tens of mmf.



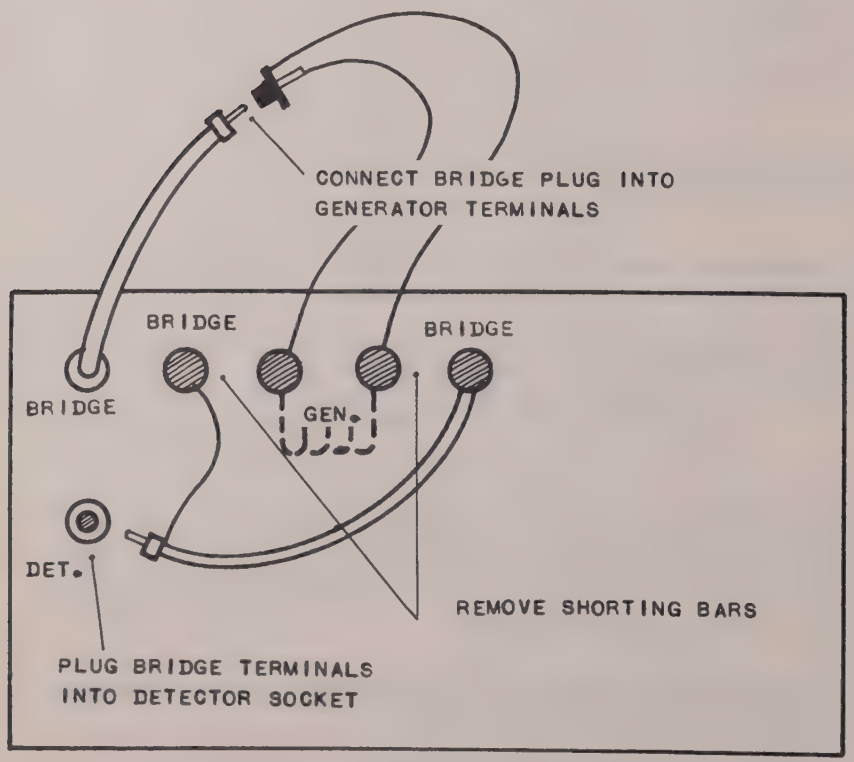
2.3.3. Grounded Capacitance Measurements

Because of inherent errors in making grounded capacitance measurements, the Model 270 Capacitance Bridge has been designed for ungrounded operation. For a grounded measurement several precautions and bridge changes are necessary. In making a grounded measurement the accuracy of the measurement may be reduced.

The generator and detector corners of the bridge must be interchanged. This is done be making the connections shown in the sketches below:



Bridge connections for grounded measurements



Circuit change for grounded measurements
(Top view of bridge with cover raised)

This connection throws nearly 100 mmf of internal capacitance across the unknown terminals of the bridge, so that a zero capacitance measurement is necessary. No appreciable correction will be needed for large capacitances.

2.3.3.1. Procedure:

Make the necessary changes in the bridge circuit.

With nothing connected to the terminals, balance the bridge.

Record these values as C_o and D_o.

Connect the ground side of the capacitor to the right-hand terminal of the bridge.

Connect the other terminal of the capacitor to the center terminal of the bridge.

Balance the bridge.

Record these values as C_m and D_m.

Compute the values of the unknown capacitor, C_x and D_x from the following equations:

For approximate values--

$$C_x = C_m - C_o$$

$$D_x = \frac{C_m D_m - C_o D_o}{C_x}$$

For maximum accuracy--

$$D_x = \frac{C_m D_m (D_o^2 + 1) - C_o D_o (D_m^2 + 1)}{C_m (D_o^2 + 1) - C_o (D_m^2 + 1)}$$

$$C_x = (D_x^2 + 1)\left(\frac{C_m}{D_m^2 + 1} - \frac{C_o}{D_o^2 + 1}\right)$$

2.3.3.2. Expected accuracy:

With grounded connections, the accuracy after calculation is approximately as follows:

$\pm$(1% + 1 mmf) for capacitance

$\pm$(.001 + 5% of reading) for dissipation factor

2.4. THINGS TO WATCH OUT FOR

2.4.1. Low Capacitance Measurements

In making low capacitance measurements, there are two things to watch out for:

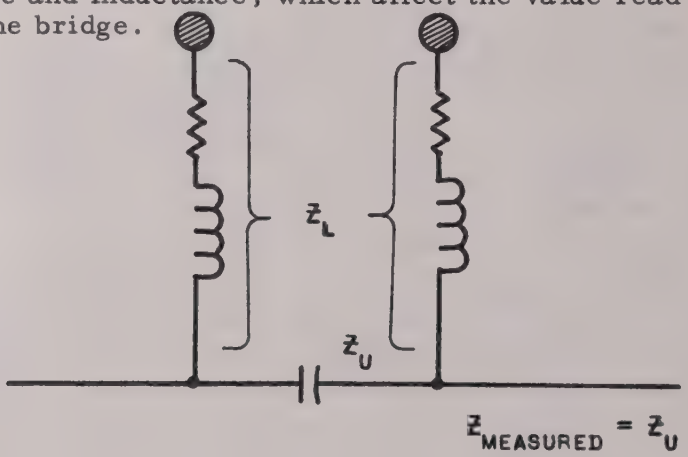
Be careful to avoid hum pickup.
Keep the stray capacitance at a minimum.

To minimize both effects, keep your hands as far as possible from the capacitor being measured.

Keep the leads as short and direct as possible. If extended leads are necessary, the lead from the center terminal should be shielded. See section 2.9., "Extended Leads."

2.4.2. High Capacitance Measurements

The bridge measures the total impedance connected to its terminals. Both the unknown capacitor and its leads contribute to this impedance. The leads have some resistance and inductance, which affect the value read from the bridge.



$\bar{Z}_U$ = Impedance of unknown capacitor

$\bar{Z}_L$ = Impedance of leads

For the greatest accuracy, minimize the lead impedance. Short heavy leads will reduce the resistance. Closely-spaced twisted leads will reduce the inductance and the pickup of stray fields.

2.5. POLARIZING VOLTAGE

2.5.1. When to use a Polarizing Voltage

Some capacitors need a polarizing voltage. For example, electrolytic and tantalytic units can be damaged by the reverse polarity half-cycle of the test frequency. Even if the capacitors are not damaged, erroneous readings may result.

2.5.2. When a Polarizing Voltage is Not Necessary

A polarizing voltage is not always needed in these measurements. If the ac voltage is kept at a very low value, the capacitor will not be damaged, and the readings will be reasonably accurate.

Because of the high sensitivity of the Model 270 bridge, accurate measurements can be made with a very low oscillator voltage. When operating with a low oscillator voltage, be sure that the detector sensitivity is maximum.

2.5.3. How to Supply a Polarizing Voltage

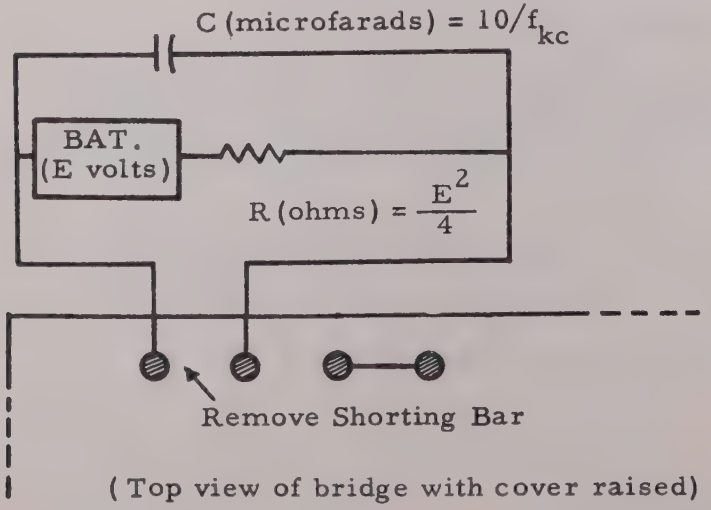
Terminals are provided on each side of the generator transformer for the insertion of a polarizing voltage.

Keep the dc source well insulated, and keep the capacitance to ground as small as possible. Use of a battery is recommended.

The maximum recommended polarizing voltage is 300 v.

The polarizing voltage should be in series with the ac generator. Direct current is then blocked from flowing through the bridge by the unknown capacitor in one arm, and the standard capacitor in the other arm.

The dc source should be by-passed by a capacitor. A current limiting resistor will protect the bridge from damage in case of short circuits.



(Top view of bridge with cover raised)

2.6. VOLTAGE MEASUREMENT

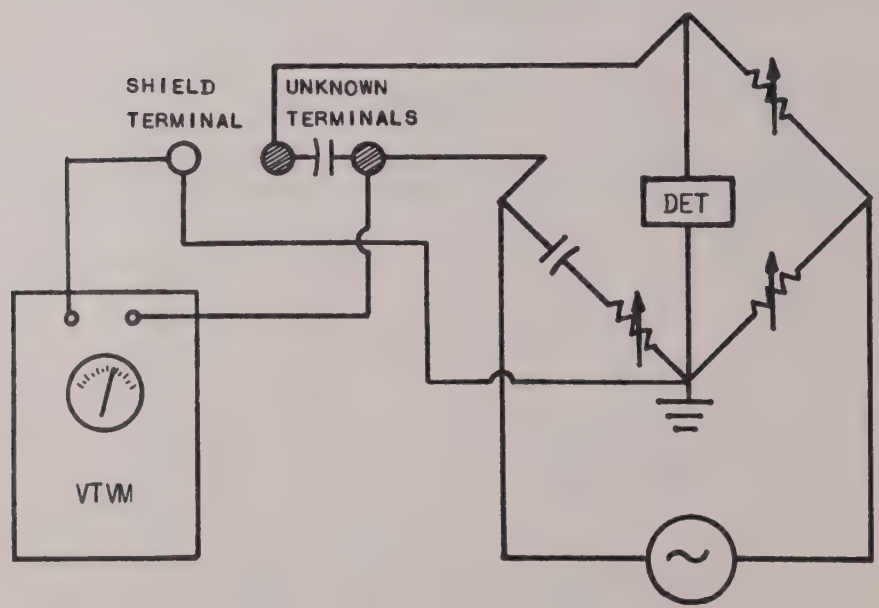
To measure the ac voltage applied across the unknown capacitor:

Connect the ground terminal of a high impedance ac voltmeter to the shield terminal of the bridge.

Connect the input terminal of the voltmeter to the right-hand terminal of the bridge.

Balance the bridge.

Read the voltmeter. With the bridge balanced, this voltage is equal to the ac voltage across the unknown capacitor, but the capacitor has not been loaded by the voltmeter. The bridge readings, however, may be incorrect while the meter is connected.



2.7. EQUIVALENT SERIES RESISTANCE AND STORAGE FACTOR

The bridge measures effective series capacitance and dissipation factor. From these values, storage factor and equivalent series resistance can be calculated.

$$Q = \frac{1}{D}$$

$$R_s = \frac{D}{2\pi f C_s}$$

Q = Storage factor

R_s = Equivalent series resistance, in kilohms

D = Measured dissipation factor

C_s = Measured equivalent series capacitance, in mf

f = Frequency, in kilocycles

2.8. EQUIVALENT PARALLEL CIRCUIT

From the equivalent series capacitance and dissipation factor measured, the equivalent parallel circuit can be derived.

$$Q = \frac{1}{D}$$

$$C_p = \frac{C_s}{1 + D^2}$$

$$R_p = \frac{1 + D^2}{D^2} R_s = \frac{1 + D^2}{D} \frac{1}{2\pi f C_s}$$

Q = Storage factor

C_p = Equivalent parallel capacitance, in mf

R_p = Equivalent parallel resistance, in kilohms

D = Measured dissipation factor

C_s = Measured equivalent series capacitance, in mf

R_s = Equivalent series resistance, in kilohms

f = Frequency, in kilocycles

The D of the equivalent parallel circuit always equals the D of the equivalent series circuit. The same is true of Q.

2.9. EXTENDED LEADS

Sometimes it is necessary to use extended leads. This can be done easily, without causing error in the measurement.

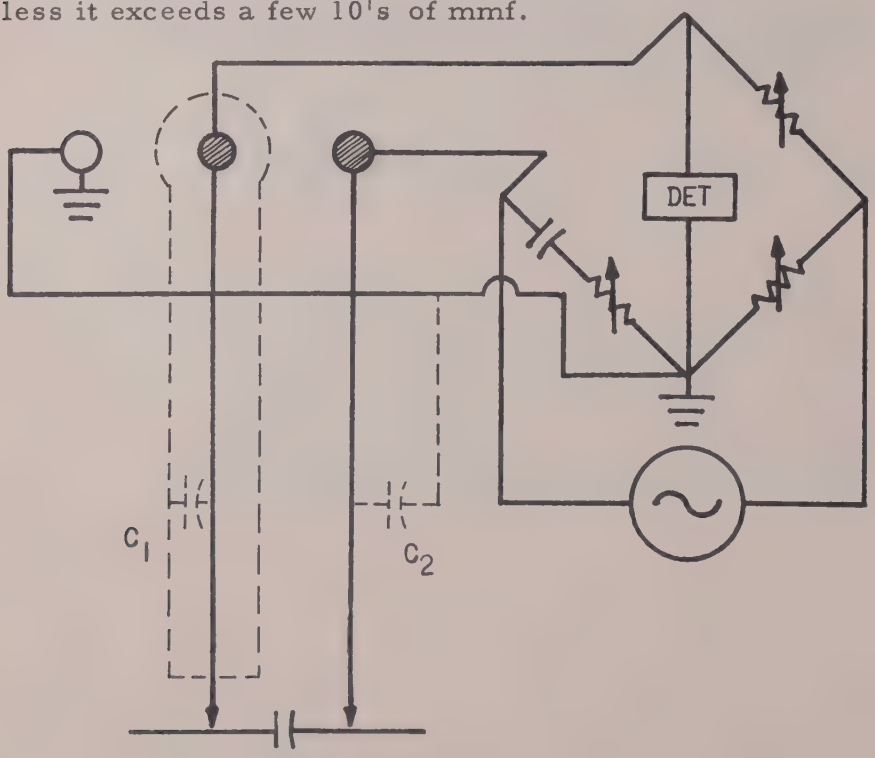
Connect a shielded lead to the center terminal.

Connect the shield of this lead to the shield terminal of the bridge.

Connect an ordinary clip lead to the right-hand terminal.

The capacitance between the shield and the center conductor is now across the detector. This keeps it from causing any error. If this stray capacitance is greater than 500 mmf, it may reduce the detector sensitivity.

The stray capacitance from the unshielded lead to ground is across the standard capacitance arm of the bridge. As the standard capacitor is 100,000 mmf, the stray capacitance will not cause significant errors unless it exceeds a few 10's of mmf.



C_1: Capacitance from center conductor to ground

C_2: Capacitance from unshielded conductor to ground

3. SPECIFICATIONS

Capacitance Range:

0 to 120 microfarads in 7 ranges

0.01 micromicrofarad per dial division on the lowest range

Accuracy: ±(0.20% + 1 dial division). Slightly larger errors may be encountered on the highest and lowest capacitance ranges.

Dissipation Factor Range at 1 kc:

0 to 1.05 in 3 ranges

0.0001 per dial division on lowest range

Accuracy: ±(0.0005 + 2% of the reading). Slightly larger errors may be encountered on the highest and lowest capacitance ranges.

4 MAINTENANCE

4.1 Cleaning of Slide-Wire Rheostat

Remove rear bridge cover.

Remove DEKASTAT dust cover. Follow instructions on dust cover.

Using a small strip of crocus cloth, wipe both slide wires. Make two or three continuous rotations. Care should be taken to rotate the slider out of the way to avoid changing its contact force. To complete cleaning, wipe slide-wires and contacts with a clean, dry, lint-free cloth to remove loose particles

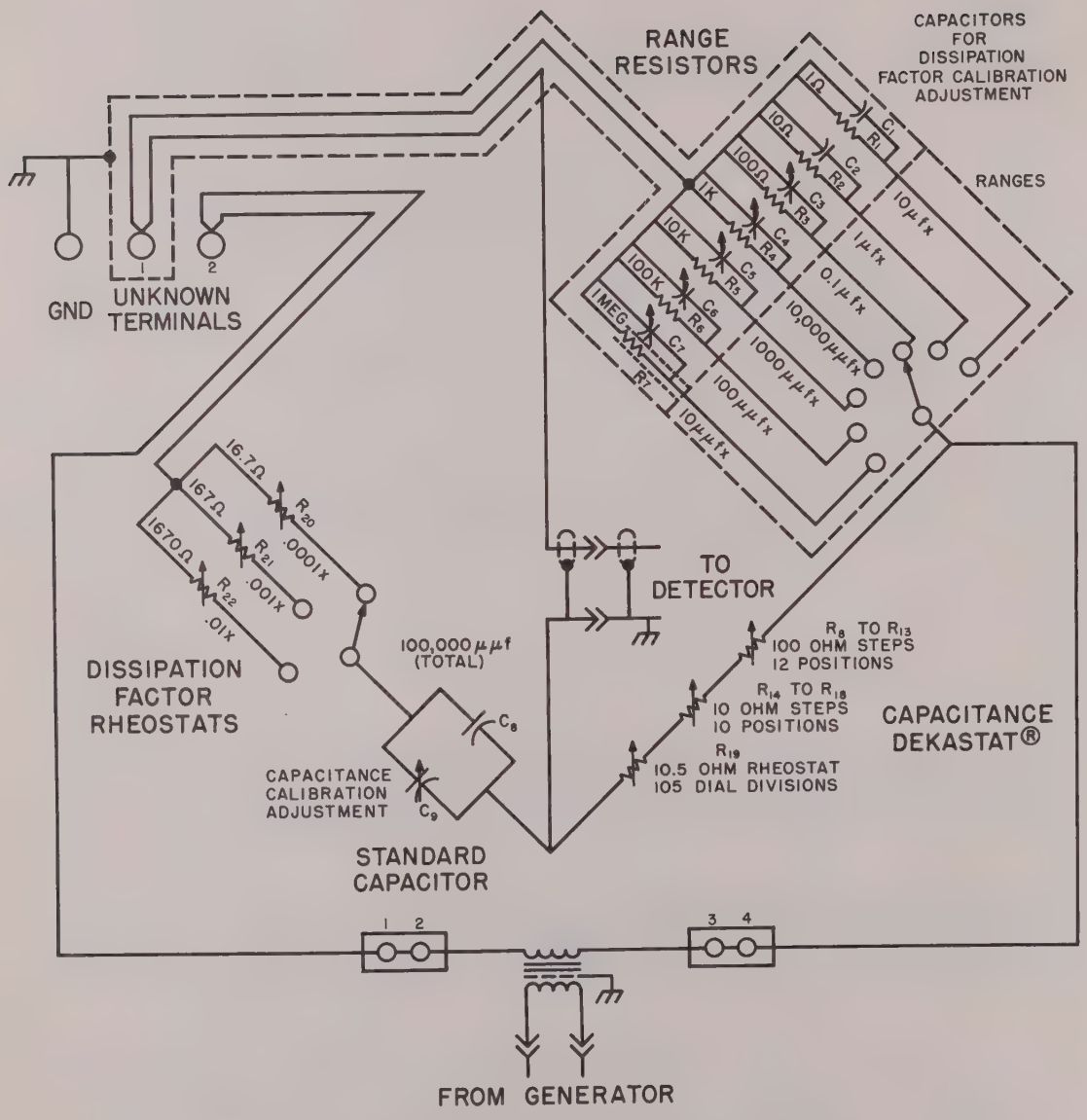
4.2 Adjusting Slide-Wire Rheostat

It is recommended that instrument be returned to factory if slide-wire contacts require adjustment. Where it is absolutely necessary to make repairs yourself, adjust each slider so that contact force measures 75 to 100 grams. USE EXTREME CAUTION to avoid damaging slide-wires.

GENERATOR DETECTOR COMPONENT PARTS

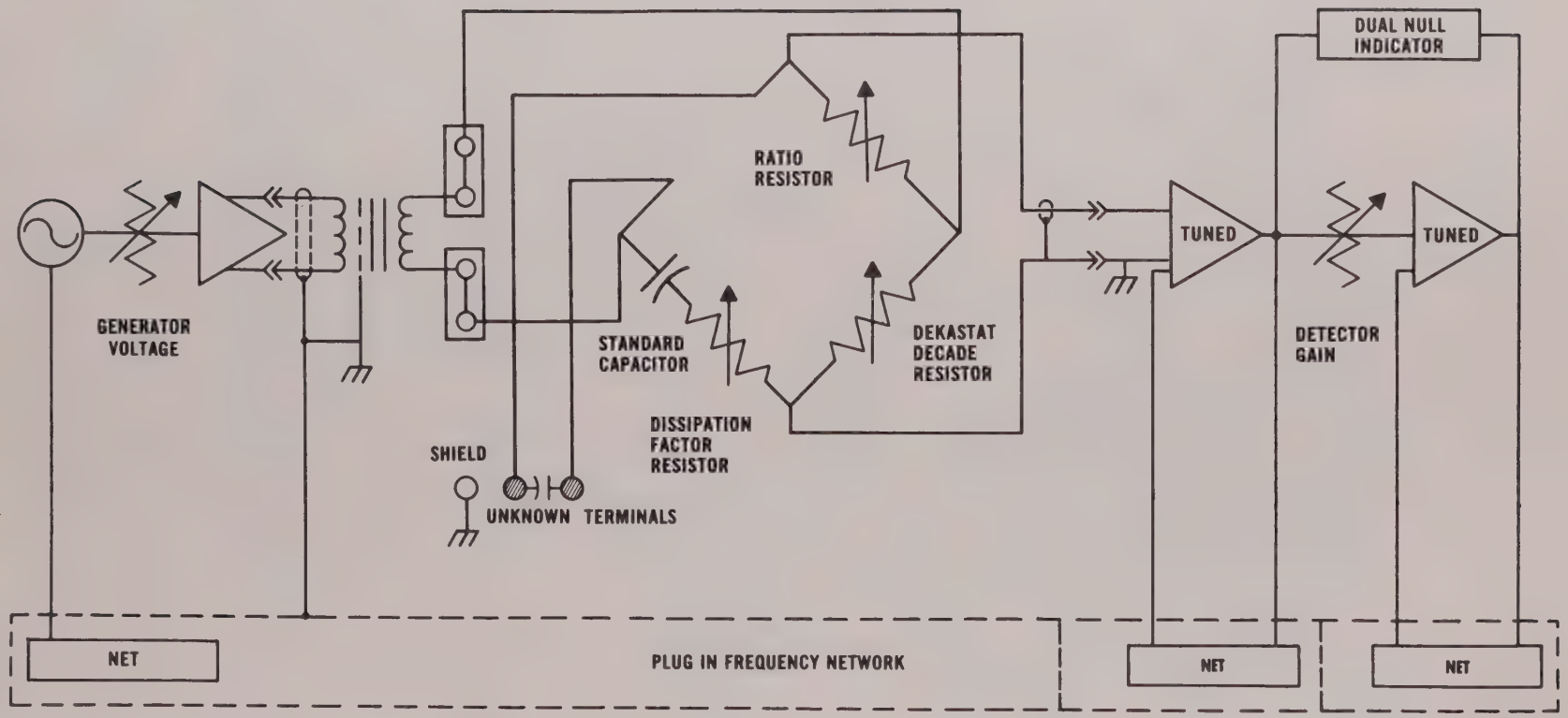
R-1	470K	10%	1/2W
R-2	10,000Ω	10%	1/2W
R-3	1.8 meg	10%	1/2W
R-4	180K	1%	1/2W
R-5	180K	1%	1/2W
R-6	47,000Ω	10%	1/2W
R-7	4,700Ω	10%	1/2W
R-8	10,000Ω	10%	1/2W
R-9	1.8 meg	10%	1/2W
R-10	180K	1%	1/2W
R-11	180K	1%	1/2W
R-12	2,700Ω	10%	1/2W
R-13	100K	10%	2W
R-14	47,000Ω	10%	1/2W
R-15	47,000Ω	10%	1/2W
R-16	22,000Ω	10%	1/2W
R-17	1,500Ω	10%	1/2W
R-18	22,000Ω	10%	1/2W
R-19	22,000Ω	10%	1W
R-20	100Ω	10%	1/2W
R-21	2.7 meg	10%	1/2W
R-22	180K	1%	1/2W
R-23	180K	1%	1/2W
R-24	820Ω	10%	1/2W
R-25	10 meg	10%	1/2W
R-26	470K	10%	1/2W
R-27	1.5 meg	10%	1/2W
F-1, F-2	1 amp		3 AG

SR-1, SR-2		20 ma, 320V Selenium rectifier	
V-1	6U8A		
V-2	6U8A		
V-3	6AF6-G		
V-4	12AT7		
P-1	500K	10%	2W
P-2	500K	10%	2W
S-1	SPST	2A	125V
T-1	500VCT	20 ma. d.c.	
	6.3VCT	2a.	
C-1	0.01 µf	±20%	400V
C-2	25 µf		25V
C-3	0.01 µf	±20%	400V
C-4	15-15-15-15 µf		450V
C-5	15-15-15-15 µf		450V
C-6	15-15-15-15 µf		450V
C-7	15-15-15-15 µf		450V
C-8	25 µf		25V
C-9	0.1 µf	±20%	400V
C-10	0.01 µf	±20%	400V
C-11	0.01 µf	±20%	400V
C-12	0.01 µf	±20%	400V
C-13	33 µµf	5%	400V



5.1 MODEL 270 CAPACITANCE BRIDGE CIRCUIT DIAGRAM

GENERATOR • • • • • BRIDGE • • • • • DETECTOR



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MODEL 270 CAPACITANCE BRIDGE BLOCK DIAGRAM

CLAIM FOR DAMAGE IN SHIPMENT

This instrument should be tested upon receipt. If it fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be forwarded to us by the claim agent. We will then advise you of the disposition to be made and arrange for repair or replacement. Include model and serial number when referring to this instrument.

WARRANTY

Electro Scientific Industries, Inc. warrants each instrument and component parts to be free from defects in material and workmanship. Electro Scientific Industries, Inc. will service any instrument and replace parts thereof (except tubes, fuses and batteries) which shall, within one year after making delivery to the original purchaser, prove to be unsatisfactory.

If the fault has been caused by misuse or abnormal conditions or operation, a nominal charge will be made for repairs. In this case, an estimate will be submitted before making such repairs.

Electro Scientific Industries, Inc. reserves the right to make changes in design at any time without incurring obligation to modify units previously purchased.

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ESI instruments are carefully engineered and made to the most exacting standards of workmanship and accuracy in a modern and well-equipped factory.

Field Engineers are maintained in principal cities as a service to our customers. Customers are invited to contact our nearest field engineer or to consult our engineering staff for further information regarding ESI instruments and their applications.

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BRIDGES AND ACCESSORIES
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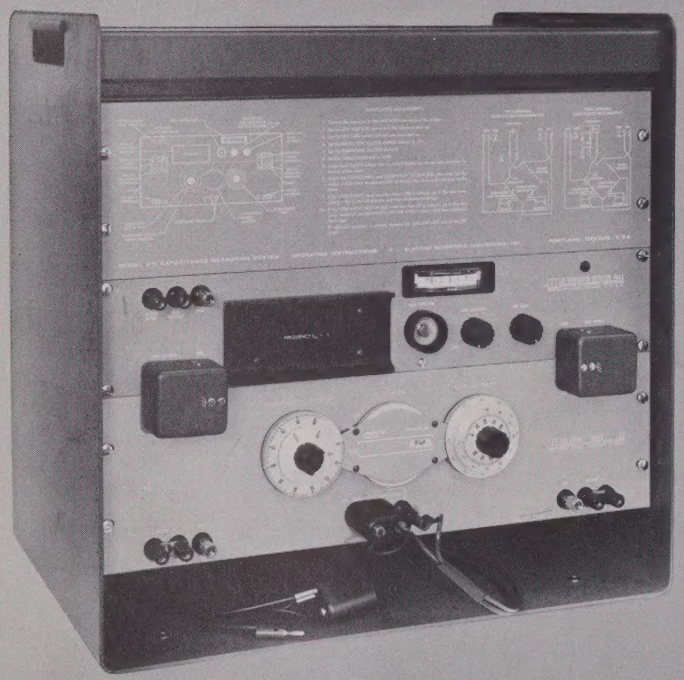

CAPACITANCE MEASURING SYSTEM

MODEL 271

Wide Range Measurements with 0.1% Accuracy

The ESI Model 271 Capacitance Measuring System consists of the ESI Model 277 Capacitance Bridge and the ESI Model 860A AC Generator-Detector mounted in a custom metal cabinet. The system has a wide range measurement capability using the precision bridge, matched generator and sensitive detector. Shielded test leads and front panel operating instructions simplify accurate measurements. Extended capacitance and dissipation factor range is available in the ESI Model 271H Capacitance Measuring System which features the ESI Model 277H Capacitance Bridge.

The Model 277 Capacitance Bridge measures two and three-terminal capacitors to 120 μf with a resolution of 0.01 picofarads on the lowest range. The Model 277H will measure to 1200 microfarads with a resolution of 0.1 picofarads on the lowest range. The unknown capacitor is measured in terms of the capacitance and dissipation factor of its equivalent series circuit. Stray capacitance in parallel with the unknown is eliminated by internal bridge shielding and by the use of shielded leads. Capacitance value and dissipation factor are presented as coaxial dial in-line readouts for fast, error-free measurements.

The Model 860A AC Generator-Detector consists of a voltage source and sensitive tuned detector designed to optimize bridge performance. The generator provides up to 15 volts output and is power limited to 0.1 watt for circuit protection. The detector is tuned to the generator frequency to minimize harmonic response and hum pickup. The panel-mounted meter gives easily observed null variations and the electron ray null indicator give instantaneous response to signal changes for rapid, precision bridge balancing. Detector output and synchronization terminals are available for connecting an external null indicator.

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esi Specifications

MODEL 277

Capacitance Readings

Number of Ranges:	Seven.
Dial Resolution:	12,005 divisions full scale on any range.
Highest Range:	0 to 120 μf.
Lowest Range:	0 to 120 pf; 1 dial division represents 0.01 pf.
Accuracy*:	On the five intermediate ranges: ±(0.1% + 1 dial division). On highest range and lowest range: ±(0.2% + 1 dial division).

Dissipation Factor Readings

Number of Ranges:	Three.
Dial Resolution:	105 divisions full scale on any range.
Highest Range:	0 to 1.05 x frequency in kilocycles.
Lowest Range:	0 to 0.0105 x frequency in kilocycles; at 1 kc, 1 dial division represents a D of 0.0001.
Accuracy*:	±(2% + 0.0005).

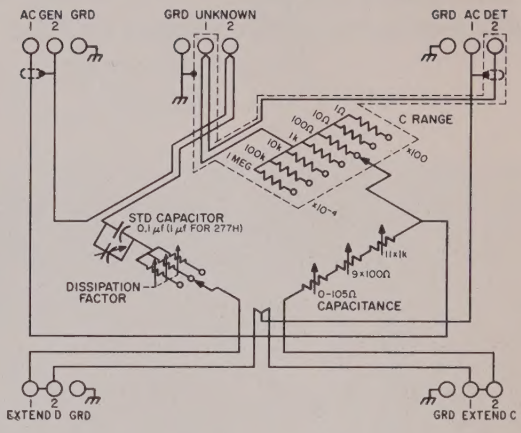
MODEL 277H

Capacitance Readings

Highest Range:	0 to 1200 μf.
Lowest Range:	0 to 1200 pf; 1 dial division represents 0.1 pf.
Accuracy*:	On the five intermediate ranges: ±(0.1% + 1 dial division). On highest range and lowest range: ±(0.2% + 1 dial division).

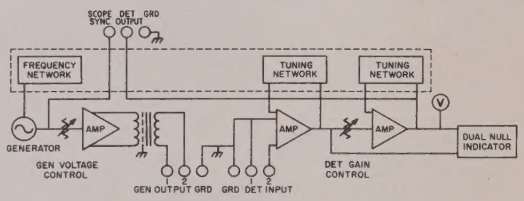
Dissipation Factor Readings

Highest Range:	0 to 10.5 x frequency in kilocycles.
Lowest Range:	0 to 0.105 x frequency in kilocycles; at 1 kc, 1 dial division represents a D of 0.001.
Accuracy*:	±(2% + 0.0005).



MODEL 860A

Generator Voltage:	0 to approximately 15 volts. Internal resistance is approximately 600 ohms. Generator output terminals are insulated from ground and have capacitance to ground of less than 30 pf.
Generator Frequency:	1 kilocycle network, accurate to ± 1% supplied. 0.1, 0.4 and 10 kilocycle units available. Units between 0.05 and 10 kilocycles made to order.
Detector Indicator:	Meter plus electron ray null indicator with instantaneous response to signal changes. Dual display for strong and weak signal changes.
Detector Sensitivity:	At maximum gain, meter and lower half of eye respond to signals, approximately 20 microvolts to 0.01 volts. Upper eye between 0.01 volts and 5 volts.
Detector Selectivity:	Network tuned to generator frequency. Second harmonic response down at least 30 db.
Power Supply:	115 volts, 50/400 cycles. 230 volt transformer available.

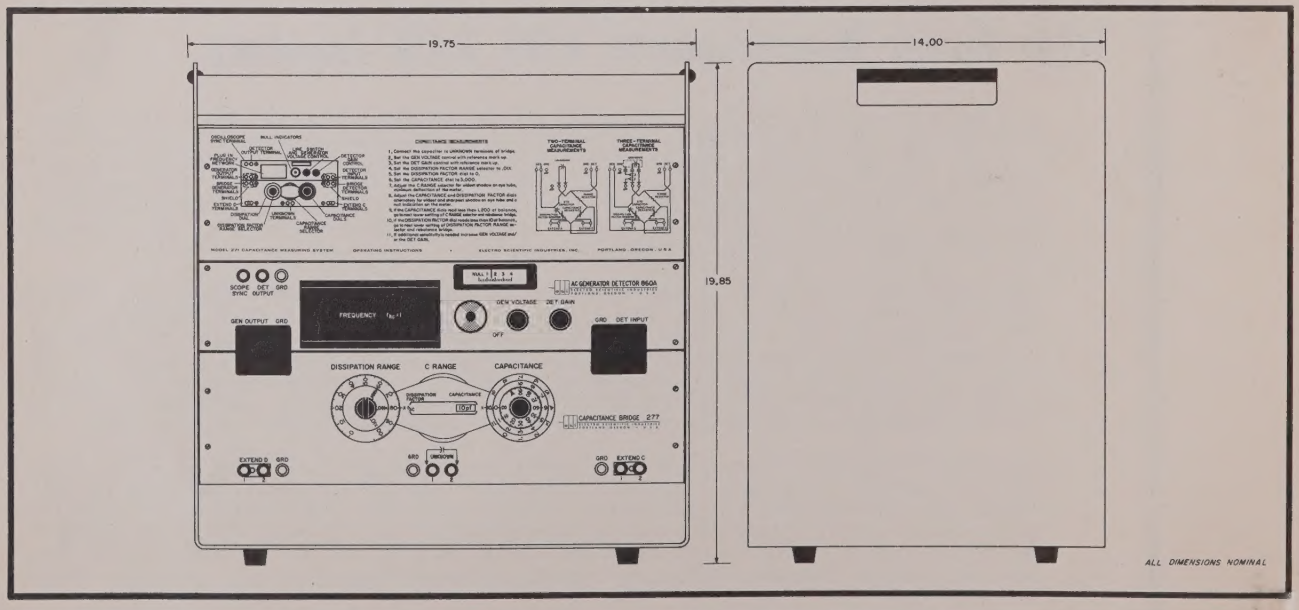


PHYSICAL SPECIFICATIONS

MODEL 271 and 271H	DIMENSION	19.75 W x 19.85 H x 14 D	NET WEIGHT 50 lbs	PRICE $ 650.00
277 and 277H		19 W x 7 H x 7 D	18 lbs	310.00
860A		19 W x 3 1/2 H x 8 D	10 lbs	280.00

PART NO. 1560 Shielded lead set (included with Model 271 and Model 271H) 12.00

*NOTE: Accuracy ratings apply at a frequency of 1 kc and at a temperature of 25°C. Slightly larger errors may be encountered at frequency or temperature extremes. Capacitance accuracy specifications apply when the bridge has been recently standardized against a reference standard capacitor. The long-term drift in calibration will not exceed 0.1% per year (Model 277), 0.2% (Model 277H) and any such drift can be corrected by a single adjustment to restandardize the bridge against any certified reference standard capacitor.



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